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Moses KAKUNGULU [1], Kevin Teopista AKOYI[1], Kaat VAN HOYWEGHEN[1], Liesbet VRANKEN[1], Moses ISABIRYE[2] and Miet MAERTENS[1]

Abstract

In this paper we present empirical evidence of the welfare effects of rural income diversification and off-farm income generation. We use household survey data from two panel rounds in rural Uganda, and fixed and random effects estimation and quantile regressions to estimate average and heterogeneous effects. While the literature mostly focuses on either income diversification or participation in off-farm activities, we specifically distinguish between income diversification, using the Simpson index of diversification, and off-farm income generation. We use ex post income and poverty measures as well as an ex ante vulnerability measure to analyze the welfare effects of income diversification out of agriculture. Our results lead to nuanced findings that complement existing insights. We find that income diversification and off-farm income generation improve household income, reduce their likelihood to be poor and reduce their vulnerability to poverty. We find quite strong average effects: a 10 percentage point increase in the Simpson index or in the share of off-farm income in the portfolio, increases per capita income with around 13 percent reduces the likelihood to be poor with around five percent. We find that it is most beneficial for poorer households with less land assets to diversify their income portfolio, while moving out of agriculture is equally beneficial at all income levels and most beneficial for households with more human capital. In addition, we find that income diversification reduces vulnerability at all income levels, but most strongly at high levels of diversification and low levels of income. Off-farm income generation reduces vulnerability at lower levels of off-farm income, while it increases vulnerability at higher levels of off-farm income generation. We conclude that income diversification serves both income growth and income smoothing while off-farm income generation mainly serves income growth.

Key Words: income diversification; off-farm income; poverty; vulnerability; Sub-Saharan Africa; Uganda

JEL classification: D1, Q1, R2

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1. Introduction

Despite progress towards the eradication of poverty, the incidence and depth of poverty in sub-Saharan Africa remains high with a poverty headcount ratio of 42.7% and a poverty gap of 16.5% (Beegle et al., 2016). Poverty is severe especially in rural areas, where the majority of people make a living from agriculture. Diversifying rural incomes away from agricultural and low-return activities into non-agricultural and high return-activities – or a structural rural transformation – is discussed as an effective and essential pathway towards upward rural income mobility and poverty reduction (Anderson Djurfeldt et al., 2018; Barrett et al., 2010 and 2017; Losch et al., 2012; McCullough, 2017; Van den Broeck and Maertens, 2017). Empirical studies, on the one hand, point to positive welfare effects of rural income diversification and participation in non-farm activities, including income-enhancing and poverty-reducing effects (e.g. Lanjouw and Lanjouw, 2001; Reardon et al., 2006; Van Hoyweghen et al., 2018) – while other studies claim that diversification leads to income smoothing rather than income growth (Barrett et al., 2001; Davis et al, 2010; Haggblade et al, 2010; Rigg, 2006). On the other hand, available evidence points out that participation in the rural non-farm economy is biased towards relatively better-off households who can overcome risk, capital and skills barriers to enter and invest in non-farm activities – resulting in increased income inequality in rural areas (Babatunde and Qaim, 2009; Bezu et al., 2012). In a review article on income diversification, Alobo Loison (2015) concludes that the growth of the rural non-farm economy in Sub Saharan Africa (SSA) is neither inclusive nor redistributive.

In this paper, we empirically analyze the welfare effects of income diversification and participation in the rural non-farm economy using household survey data from two panel rounds in the Mount Elgon region in eastern Uganda, and fixed and random effects estimation and quantile regressions. Our study is complementary to the existing literature on rural income diversification in SSA. First, we specifically distinguish between income diversification and off-farm income generation. We use the Simpson index and the share of off-farm income in total household income to measure income diversification and off-farm income generation respectively. Income diversification, which means holding a diversified portfolio of income-generating activities, might be a specific livelihood strategy of rural households but might also be a transition phase in the process of moving out of agriculture. This implies that income diversification and off-farm income generation are not necessarily highly correlated and that

they might have different welfare implications. The literature largely treats income diversification and rural non-farm income generation as two sides of the same coin; and empirical studies most often specifically focus on either diversification or off-farm activities. By including measures of both income diversification and off-farm income generation, we are able to bring some nuances in the literature on income portfolios in rural areas in SSA. Second, we specifically look into heterogeneous welfare effects to understand who benefits most from income diversification and off-farm income generation. We reveal which factors condition the welfare effects of income diversification and off-farm income generation through interaction terms in the regression models; and we estimate heterogeneous effects along the welfare distribution using quantile regression techniques. Insights on possible heterogeneous effects of rural income diversification and off-farm income generation are scarce while understanding who benefits most is important from a policy perspective (Losch et al., 2012; Winters et al., 2010). Third, we use different welfare measures in our analysis. In addition to income and monetary poverty as static welfare measures, we also analyze vulnerability, defined as the probability that future household income falls below the poverty line, as a dynamic measure of welfare (Chaudhuri et al., 2002; Van Hoyweghen et al., 2018). With this approach we further nuance the debate on income diversification and off-farm income generation in SSA, and also contribute to the literature on vulnerability to poverty, in which empirical evidence is very scarce (Klasen and Waibel, 2014). Fourth, the use of panel data is an advantage – panel data evidence is still rather scarce in the literature on income diversification in SSA – and allows us to exploit both the variation within and between households to estimate the welfare effects of income diversification and off-farm income generation, and to better control for unobserved heterogeneity. Finally, the context of our study in eastern Uganda is a situation of increasing pressure on land, land fragmentation, deforestation, cultivation on steep slopes and marginal land, intensified cultivation and soil fertility decline. While our case-study approach clearly has limitations in terms of generalizing findings, a focus on income portfolios and household welfare is particularly relevant in this context.

2. Literature review

2.1. Income diversification and off-farm income generation

On the one hand, income diversification can be a livelihood strategy of rural households. Households may allocate their productive assets and family labor among various economic activities, including self-employment and wage employment in different sectors, including agricultural and non-agricultural sectors, and locations (Abdulai and CroleRees, 2001; Alobo

Loison, 2015; Davis et al., 2010; Losch et al., 2012; Winters et al., 2010). Such a deliberate income diversification strategy might be related to risk management behavior and serve income smoothing rather than (or in addition to) income growth (Barrett et al., 2001; Dercon, 2002; Ellis, 2000; Haggblade et al., 2010; Reardon et al., 2006). On the other hand, income diversification can be a transition phase in the process of moving out of agriculture (Anderson Djurfeldt et al., 2018; Van den Broeck and Maertens, 2017). Rural households might enter off-farm employment and/or invest in non-farm businesses gradually by investing in productive assets, building up skills and relaxing liquidity constraints (Cunguara et al., 2011; Ellis & Freeman, 2004). This may result in a temporary situation of diversified income portfolios with farm and non-farm activities but ultimately lead to a situation of specialization in higher return non-farm activities in the long run.

Whether income diversification is an intentional livelihood strategy to smooth and/or augment income, or a temporary phase in the process of moving out of agriculture, has potentially important research implications. If diversification is a temporary result of households moving out of agriculture, income diversification and off-farm income generation may only be highly correlated at low to medium levels of diversification. Existing studies focus on either income diversification using the Simpson index or Herfindahl index as indicators (e.g. Barrett et al., 2001; Naznin et al., 2015; Sahal and Baha, 2010), off-farm income generation in general (e.g. Babatunde and Qaim, 2009; Barrett et al., 2001; Bezu et al., 2012; Davis et al. 2010; Lanjouw and Lanjouw, 2001), or non-farm wage employment specifically (e.g. Haggblade et al., 2010; Imai et al., 2015; Van Hoyweghen et al., 2018). To the best of our knowledge, no study in the literature combines a focus on income diversification and off-farm income generation, as we do in this paper. Second, welfare effects of income diversification may differ depending on whether households are moving out of agriculture or deliberately diversifying their income portfolio and therefore, also differ across households. No study has looked at heterogeneous effects across households, as we do in this paper.

Rural income diversification and off-farm income generation have been studied in different contexts – including studies in Asia (Imai et al., 2015; Kijima and Lanjouw, 2005; Naznin et al., 2015) and SSA (Babatunde and Qaim, 2009; Barrett et al., 2001; Bezu et al., 2012; Ellis and Freeman, 2004; Haggblade et al., 2010) – and using different methods. Studies have analyzed the implications of income diversification and off-farm income generation for household income (Barrett et al., 2001; Kijima and Lanjouw, 2005), consumption (Cunguara et al., 2011; Naznin et al., 2015), poverty (Haggblade et al., 2010; Imai et al., 2015), food

security (Zereyesus et al., 2017) and vulnerability (Imai et al., 2015, Van Hoyweghen at al., 2018) – and mostly point to positive welfare effects. While older studies mainly rely on cross-sectional data, more recent studies use panel data that allow to better identify the welfare implications of income diversification and to analyze dynamics over time (Babatunde & Qaim, 2009; Bezu et al., 2012; Kijima and Lanjouw, 2005; Lay et al., 2008).

2.2. Poverty and vulnerability

Poverty can be temporary, with people moving in and out of poverty if their income and consumption levels fluctuate, or chronic, with people persistently at income and consumption levels below the poverty line. A static poverty measure does not distinguish between temporary and chronic poverty, while understanding this distinction is crucial for eradicating poverty in SSA (Cahyadi and Waibel, 2015; Hohberg et al., 2018). Vulnerability, defined as the likelihood to be poor in the near future, has been put forward as a useful measure to capture the intertemporal nature of poverty (Chaudhuri et al., 2002). Despite a growing number of conceptual and methodological studies on vulnerability (e.g. Bogale, 2012; Celidoni, 2013 & 2015; Dutta et al., 2011; Günther & Harttgen, 2009; Hohberg et al., 2018; Hoddinott & Quisumbing, 2010; Hoogeveen, 2005; Ligon and Schechter, 2003; Povel, 2014;), the empirical applications of the vulnerability concept remain rather limited (e.g. Cahayadi and Waibel, 2015; Imai et al., 2011; Klasen and Waibel, 2014 & 2013; Van Hoyweghen et al., 2018; Ward, 2016; Zereyesus et al., 2017).

Studies on the welfare implications of income diversification and off-farm income generation usually focus on static measures of welfare, such as per capita income, consumption and poverty. We could identify three studies that include a vulnerability measure to assess the welfare implications of income diversification and off-farm income generation. Zereyesus and co-authors (2017) and Imai and co-authors (2015) find that participation in non-farm activities reduces vulnerability to (food) poverty in respectively Ghana, and in Vietnam and India. Van Hoyweghen and co-authors (2018) show that participation in off-farm wage employment contributes to reducing vulnerability to poverty in rural Senegal. We add to this evidence, and to the empirical application of the vulnerability concept, with a study on income diversification and off-farm income generation in Uganda.

3. Data and methods

3.1. Study area and data collection

Our research is conducted in the Mount Elgon region in Eastern Uganda, characterized by a high population density, increasing land pressure and fragmentation. Farm-households in the region practice mixed cropping, most commonly cultivating coffee, bananas, maize and beans on one to two hectares of land (Mugagga and Buyinza, 2013). Soil fertility is declining and cultivation is increasingly done on marginal lands, such as on steep slopes, making the region extremely prone to landslides (Knapen et al., 2006).

In this region, we conducted two rounds of a quantitative household survey in 2014 and 2016. The initial sample includes 600 households, selected in a multistage sampling design. In the first stage, five of the eight districts (Bududa, Manafwa, Sironko, Bulambuli and Kapchorwa) in the Mount Elgon region were purposively selected. The more urbanized districts of Mbale and the less densely populated districts (Kween and Bukwo), close to the border with Kenya were excluded. In the second stage, villages in the five districts were stratified into three classes according to altitude and 20 villages were selected in each strata. In the third stage, ten households in each of the 60 villages were randomly selected. For the second survey round, 100 households were intentionally and randomly dropped from the initial sample – in order to sample an additional 200 households from the border districts (Kween and Bukwo) – and another 42 households unintentionally dropped out of the sample. The latter corresponds to an attrition rate of 8.4 %. With this rather limited attrition, and because no significant differences could be detected in observed characteristics between drop-out and second-round households, attrition bias is likely limited. For the analysis in this paper, we use data from a balanced panel of 458 households.

A quantitative questionnaire, structured in different topical modules, was used in both survey rounds. Some modifications were made to the questionnaire in between survey rounds but information on farm and non-farm activities and income was asked in the same way. The survey data include information on household demographics, land ownership and management, agricultural production and marketing, forest interaction, non-land asset holdings, off-farm wage employment, self-employment and non-labor income. The survey rounds were implemented by a team of trained enumerators, using tablets and computer-assisted personal interviewing software. Household survey data are complemented with data from a quantitative village survey in all sampled villages, including information on institutions, infrastructure, accessibility and agro-ecology; and with qualitative information from semi-structured

interviews with district agricultural officers, community development officers and sub-county chiefs on rural livelihood strategies, land management and population growth.

3.2. Indicators

3.2.1. Income diversification and off-farm income

We capture income diversification and off-farm income generation with two indicators. We use the Simpson Index (SI) as a measure of income diversification. The SI is considered most suitable for measuring income diversification because it takes into account both the number of income sources and the distribution of income between different sources (Naznin et al., 2015). To calculate the SI, we distinguish between six broad income sources: cropping, livestock-rearing, non-farm businesses (non-farm self-employment), wage employment, collection of forest products and non-labor income (public and private transfers). The index is calculated as follows with *S* being the share of income source *i* in total household income:

$$SI = 1 - \sum_{i=1}^{6} S_i^2 \qquad (1)$$

The value of the SI ranges from 0 to 1, and is increasing with the level of diversification. To present descriptive statistics, we generate income diversification categories based on the SI and using the criteria of Sahal and Baha (2010): households with a *slightly diversified* income portfolio (SI< 0.38); a *moderately diversified* income portfolio ($0.38 \leq SI < 0.63$); and a *highly diversified* income portfolio *(*$SI \geq 0.63$). For the second indicator, we calculate the share of off-farm income (including income from non-farm businesses, wage employment, collection of forest products and non-labor income) in total household income.

3.2.2. Welfare indicators

We use three different welfare indicators: income, poverty and vulnerability. Income is measured in per capita terms and calculated as the ratio of total household income to total household size. Total household income is the income a household earned during the 12 month-period before the survey, including net income from crop and livestock production, net income from non-farm businesses, wages and salaries, income from forest products, and income from private and public transfers and rents. Crop and livestock income is calculated as the value of crop and livestock production, including non-marketed output valued at current market prices, minus variable production costs, including purchased inputs, hired labor and land rent. Income data for 2014 are inflated to 2016 price levels, using IMF data on consumer price indices, in order to compare real income over time. Poverty is measured with a dummy variable indicating whether or not the annual income per adult equivalent falls below the

international poverty line. We use the modified OECD adult equivalence scale with a weight of 1 for the household head, 0.5 for each additional adult member and 0.3 for household members aged 14 or below. A household is considered to be poor if per adult equivalent income falls below the international poverty line of $3.10 (measured in 2011 PPP prices), which is equivalent to UGX 3,552 (measured in real 2016 terms).

Vulnerability is measured using the method proposed by Chaudhuri et al. (2002) and is defined as the probability that the future income $Y_{i,t+1}$ of household i in period $t+1$ will fall below the poverty line λ. This is expressed as follows:

$$V_{it} = \Pr\left(Y_{i,t+1} \leq \lambda\right) = \Phi\left(\frac{\lambda - \hat{Y}_{i,t}}{\sqrt{\hat{\mu}_{i,t}^2}}\right) \quad (2)$$

Since future income $Y_{i,t+1}$ is unobserved, vulnerability is derived from the expected income $\hat{Y}_{i,t}$ and the variance of income $\hat{\mu}_{i,t}$ using the cumulative density function of the standard normal distribution, Φ. The expected income $\hat{Y}_{i,t}$ and the variance of income $\hat{\mu}_{i,t}$ are estimated separately for 2014 and 2016 to maximize the explanatory power of the regressions:

$$Y_{i,t} = \alpha X_{i,t} + \beta Z_j + \mu_{i,t} \quad (3)$$

Where $X_{i,t}$ is a vector of household characteristics and Z_j is a vector of village characteristics to control for covariate shocks. We estimate the income equation and obtain the residuals, $\hat{\mu}_{i,t}$. The squared residuals $\hat{\mu}_{i,t}^2$ are the variance of the idiosyncratic component of income. As proposed by Chaudhuri et al. (2002), since the error term is assumed to be heteroscedastic, we apply a three-step feasible generalized least squares (FGLS) technique to estimate equation 3 and obtain consistent and efficient estimates of the error term. The results of the FGLS models are reported in table A1 in appendix. The resulting vulnerability measure V_{it} is a continuous variable ranging from 0 to 1, with higher values indicating higher vulnerability levels. For the descriptive analysis we use 0.5 as threshold, as is most common (Chaudhuri et al., 2002). This implies that households are considered to be vulnerable if their probability to fall below the poverty line is 0.5 or above. Highly vulnerable households may be those who are currently poor and are likely to remain poor as well as households who are currently not poor but are very likely to fall into poverty.

3.3. Econometric Approach

To analyze the impact of income diversification and off-farm income generation on household welfare, we use three different sets of models and techniques. First, we estimate average welfare effects using models of the following generic form:

$$Y_{i,t} = \alpha + \beta I_{i,t} + \gamma X_{i,t} + \delta Z_j + d_t + u_i + \varepsilon_{i,t} \quad (4)$$

We estimate different models for three different outcome variables $Y_{i,t}$ expressing the welfare of household *i* at time *t:* income (specified in per capita and logarithm terms), poverty and vulnerability as defined in section 3.2. The key explanatory variable $I_{i,t}$ is either a measure of income diversification (SI) or a measure of off-farm income generation (share of off-farm income) as defined in section 3.2. Control variables include a vector of observable household characteristics, $X_{i,t}$ (gender, age and education of the household head, number of adults and children, and land and livestock holdings), a vector of village characteristics, Z_j (altitude, distances to the road, market and forest), and a time fixed effect d_t capturing macro-economic trends and weather variability. The vectors of control variables $X_{i,t}$ and Z_j are not included in the regressions on vulnerability as the same variables are used to estimate the indicator. The error term includes a time-invariant component u_i and a time-variant component $\varepsilon_{i,t}$. Our main interest is in the coefficient β measuring the effect of income diversification and off-farm income generation on household welfare. We explore possible quadratic effects by estimating equation 4 with and without a quadratic term of $I_{i,t}$. To exploit both variability within and between households, we estimate the models using both fixed effects (FE) and random effects (RE) regression techniques. We use linear regression models; for the binary outcome indicator poverty this implies a linear probability model. While in the FE model time-invariant unobserved heterogeneity is controlled for, the models might still suffer from reverse causality. To unravel the direction of causality, we estimate the effect of income diversification in 2014, $I_{i,2014}$ on income growth over the panel period ($Y_{i,2016} - Y_{i,2014}$) as well as the effect of income in 2014 $Y_{i,2014}$ on the change in income diversification over the panel period ($I_{i,2016} - I_{i,2014}$) – as in equation 5 and 6 and using difference-in-difference (DiD) estimation. The coefficients β' and β'' measure the effect of diversification on income and the effect of income on diversification respectively.

$$Y_{i,2016} - Y_{i,2014} = \alpha' + \beta' I_{i,2014} + \gamma' X_{i,2014} + \delta' Z_j + \varepsilon_i' \quad (5)$$

$$I_{i,2016} - I_{i,2014} = \alpha'' + \beta'' Y_{i,2014} + \gamma'' X_{i,2014} + \delta'' Z_j + \varepsilon_i'' \quad (6)$$

Second, we analyze heterogeneous welfare effects by including interaction terms between $I_{i,t}$ and $X_{i,t}$ in equation (4). We include in separate models interaction terms between the SI or the share of off-farm income on the one hand, and gender, education and age of the household head, the number of adults in the household, and the household landholdings on the other hand. These models (equation 7) are estimated using RE estimation. The results allow to reveal whether the welfare effects of income diversification vary with certain characteristics of the household.

$$Y_{i,t} = \alpha''' + \beta''' I_{i,t} + \gamma''' X_{i,t} + \delta''' Z_j + \eta''' I_{i,t} X_{i,t} + d_t + u_i + \varepsilon'''_{i,t} \quad (7)$$

Third, we analyze heterogeneous welfare effects of income diversification along the welfare distribution. We use panel quantile regressions to estimate the effect of income diversification and off-farm income generation on income and vulnerability at different quantiles of the income and vulnerability distribution – as in equation 8.

$$q_\tau\left(Y_{i,t} \middle| I_{i,t} X_{i,t} Z_j\right) = \beta_\tau I_{i,t} + \gamma_\tau X_{i,t} + \delta_\tau Z_j + d_t + u_i + \varepsilon_{i,t} \quad (8)$$

The term $q_\tau\left(Y_{i,t} \middle| I_{i,t} X_{i,t} Z_j\right)$ is the τ^{th} conditional quantile of the outcome variable and τ ranges between zero and one. The coefficient β_τ represents the estimated change in the outcome variable of a change in the measure of income diversification and off-farm income generation over time at the τ^{th} quantile of the outcome distribution. This analysis is done only for continuous outcome variables, income and vulnerability.

4. Results

4.1. Household characteristics

In table 1, we present descriptive statistics for the pooled sample of households and a mean comparison for households with a slightly, moderately and highly diversified income portfolio. Nine percent of households in the sample are female-headed; the average education of the household head is 8.3 years and the average age 51 years. Households are rather large with on average 4 members above the age of 14 and 2.6 members below the age of 14. Households with a highly diversified income portfolio are less likely to be female headed and are larger. Land and livestock holdings are rather low with on average 1.76 ha of land and 2.2 tropical livestock units but are larger for households with moderately and highly diversified income portfolios. In addition, households with highly and moderately diversified income portfolios are located at lower altitude and further away from the forest; households with highly diversified income portfolios are located closer to markets and roads.

[Table 1 about here]

4.2. Household welfare

Figure 1 depicts the correlation between the two panel years for income and vulnerability; and the correlation between income or vulnerability on the one hand and income diversification or the share of off-farm income on the other hand. As one would expect, there is a quite high positive correlation between income or vulnerability in 2014 and in 2016. There is a weak positive correlation between income and the Simpson index of diversification or the share off-farm income. There is no, or even a slightly negative correlation between vulnerability and the Simpson index of diversification or the share off-farm income.

[Figure 1 about here]

In Table 2, we present descriptive statistics for income, poverty, vulnerability and the share of income from different sources. We report results of a mean comparison between 2014 and 2016 for the overall sample, and between households with a slightly, moderately and highly diversified income portfolio. Over the panel period, the average per capita income increased with 25%, poverty reduced from 61% of sampled households to 54%, and the share of vulnerable households reduced from 64% to 59%. The share of income derived from cropping – the most important income source, followed by livestock-rearing – decreased while the share of income derived from livestock-rearing and from transfers increased. In both years, households with moderately and highly diversified income portfolios have on average a significantly higher total and per capita income, are less likely to be poor and vulnerable, and derive a smaller share of income from cropping but a higher share from non-farm businesses and transfers than households with a slightly diversified income portfolio. We need to note that there is substantial mobility between the income diversification categories over the years: 46% of the households remain in the same income diversification category; 33% move to a category with less diversification (from moderately or highly diversified to slightly diversified or from highly to moderately diversified); and 21% move to a category with higher diversification (from slightly diversified to moderately or highly diversified or from moderately to highly diversified). This makes it difficult to interpret the upward welfare dynamics within the diversification categories reported in table 2.

[Table 2 about here]

4.3. Welfare effects

In table 3 we present a summary of the estimated average effects and quadratic effects of income diversification and off-farm income generation on the different outcome indicators, from FE and RE estimations. The full regression results are reported in tables A2 to A5 in appendix. The FE and RE estimations are very consistent, implying that within household variation drives the results. The results reveal that income diversification and off-farm income generation increase household income, and reduce the likelihood to be poor as well as the vulnerability to poverty – with the latter effect only being significant for the SI and not for the share of off-farm income. The estimated average effects are quite strong. We find that a 10 percentage point (pp) increase in the SI of diversification increases per capita income on average with 13% and reduces the likelihood to be poor on average with 5 pp. Likewise, an increase in the share of off-farm income with 10 pp increases per capita income with 12 to 15% on average, and reduces the likelihood to be poor with 4.2 to 4.9 pp on average. We find an indication of a quadratic effect of the share of off-farm income on per capita income (only significant in the RE estimation). We find significant effects of the quadratic terms for vulnerability, for both the SI and the share of off-farm income and in both the FE and RE models. The effects imply that with an increasing SI, vulnerability decreases at a decreasing rate; and that with an increasing share of off-farm income, vulnerability reduces up to a certain point (about 0.4 in the vulnerability distribution), after which it increases vulnerability.

[Table 3 about here]

We unravel the direction of causality between income and income diversification using DiD techniques – of which the full regression results are reported in table A6 in appendix. These DiD estimations reveal that the effect of the SI in 2014 on per capita income growth over the panel period is 1.465 (st. error 0.242 and significant at the 1% level), while the effect of per capita income in 2014 on the change in the SI over the panel period is 0.028 (st. error 0.015 and significant at the 10% level). This implies that causality runs in both directions but that the effect of income diversification on the per capita income level is more than 30 times stronger than the effect of the income level on income diversification[3].

[Table 4 about here]

In table 4 we present a summary of the estimated heterogeneous effects of income diversification and off-farm income generation on per capita income and poverty from RE

[3] The estimated β' coefficient of 1.465 in equation (5) implies that a 10% higher SI in 2014, results in a 14.6% increase in relative income growth over the panel period. The estimated β'' coefficient of 0.028 in equation (6) implies that a 15.7% higher per capita income in 2014, results in a 0.41 % increase in the SI over the panel period.

estimations with interaction terms. The full regression results are reported in tables A7 to A11 in appendix. The results show that per capita income is significantly larger and poverty significantly less likely for smaller households with more land and a better educated household head. The interaction terms reveal that the income increasing effect of diversification is smaller for households with more land and an older household head. Also the poverty reducing effect of diversification is smaller for households with more land. The income enhancing effect of off-farm income generation is stronger for larger and better educated households, but not for households with more land, and also its poverty reducing effect is stronger for better educated households.

[Table 5 about here]

In table 5 we report the results of the quantile fixed effects regressions estimating the income and vulnerability effects of income diversification and off-farm income generation at different quantiles of the income and vulnerability distribution. The full regression results are reported in tables A12 to A15 in appendix. We find significant positive effects of the SI and the share of off-farm income on per capita income at all quantiles of the income distribution, and significant negative effects for both indicators on vulnerability at almost all quantiles of the vulnerability distribution. The income increasing effect of income diversification and off-farm income generation is largest for the lowest income quantile and decreases along the income distribution. This implies that households at the lower end of the income distribution benefit relatively more from diversifying away from agriculture than households at the upper. The effect of the SI varies more strongly along the income distribution than the effect of the share of off-farm income. The estimated effect of income diversification for the lower income quantile is more than double the estimated effect for the upper income quantile while the estimated effect for the lower income quantile is only 23% higher than the estimated effect for the upper income quantile. The vulnerability reducing effect is strongest for the lowest vulnerability quantile and becomes weaker along the vulnerability distribution, which implies that the most vulnerable households benefit least from income diversification and off-farm income generation.

5. Discussion

We find that income diversification as well as off-farm income generation improve rural incomes and reduce poverty. The effects we find are quite strong with a 10 percentage point (pp) increase in the Simpson index or in the share of off-farm income, increasing per capita

income with around 13% and reducing the likelihood to be poor with around 5% on average. These quite strong income-increasing and poverty-reducing effects are in line with findings from other studies (e.g. Lanjouw and Lanjouw, 2001; Reardon et al., 2006) and imply that diversification out of agriculture in general results in rural income growth.

Moreover, we find that the income-enhancing and poverty-reducing effects of income diversification and off-farm income generation are heterogeneous across farmers. First, we find that it is particularly more beneficial for households at the lower end of the income distribution to diversify their income portfolio, and for younger households and household with less land. Second, we find that it is more beneficial for larger and more educated households to move out of agriculture, and that the effect of off-farm income generation varies less strongly along the income distribution. These varying heterogeneous effects indicate that income diversification and off-farm income generation indeed have different welfare implications, and that they should not be treated as two sides of the same coin in the literature. Our findings contradict previous conclusions in the literature that only relatively wealthier households are able to gain from rural income diversification (Ruben and Van den Berg, 2001; Canagarajah et al., 2001; Bezu et al., 2012) and that specifically resource-poor households with low farm profit potential should move out of agriculture (Rigg, 2006; Van den Broeck and Maertens, 2017). Our findings imply that especially low-income households with less assets (land) can gain from diversifying their income portfolio with agricultural and non-agricultural activities while households with human capital (labor as well as education), irrespective of their income level, can gain from moving out of agriculture. This more nuanced conclusion results from distinguishing explicitly between income diversification and off-farm income generation in this study.

We find that both income diversification and off-farm income generation reduce the vulnerability of rural households. This is in line with previous studies indicating a negative effect of off-farm income generation on vulnerability (Imai et al., 2015; Van Hoyweghen et al., 2018; Zereyesus et al., 2017) but our findings also add nuances. We find that income diversification increases per capita income and reduces vulnerability at all income levels. Off-farm income generation increases per capita income at all income levels, but only reduces vulnerability for households at the lower 50% of the income distribution and not for households at the upper 25% of the income distribution. In addition, we find that income diversification reduces vulnerability and that this effect is stronger at higher levels of income diversification. Off-farm income generation only reduces vulnerability at low levels of off-farm income and increases vulnerability at higher levels of off-farm income. These quadratic and heterogeneous effects imply that income diversification serves both income growth and income smoothing

while off-farm income generation mainly serves income growth. In rural societies where agriculture is the main income source, moving out of agriculture at first results in income diversification but ultimately leads to specialization in off-farm activities. Income diversification and off-farm income shares are therefore correlated only at lower levels of off-farm income generation and ultimately have different welfare effects, as observed in our research area. By including ex post income and poverty measures and ex ante vulnerability measures in the analysis, we are able to disentangle the diverse effects of income diversification and off-farm income generation.

6. Conclusion

In this paper we empirically analyze the welfare effects of income diversification and off-farm income generation using household survey data from two panel rounds in the Mount Elgon region in rural Uganda, and fixed and random effects estimation and quantile regressions. While the literature mostly focuses on either income diversification or participation in off-farm activities, we specifically include and distinguish between income diversification and off-farm income generation. We use income and poverty indicators as well as a vulnerability indicator to analyze the welfare effects of income diversification and off-farm income generation. Our results lead to nuanced findings that complement existing insights. We find that on average income diversification and off-farm income generation improve rural incomes, reduce poverty and reduce the vulnerability of rural households. We find that it is most beneficial for poorer households with less land assets to diversify their income portfolio while moving out of agriculture is more equally beneficial at all income levels and most beneficial for households with more human capital. In addition, we find that income diversification reduces vulnerability most strongly at high levels of diversification and low levels of income while off-farm income generation reduces vulnerability only at low levels of income and even increase vulnerability at higher levels of off-farm income generation. We conclude that income diversification serves both income growth and income smoothing while off-farm income generation mainly serves income growth.

We need to acknowledge that our results are case-study specific and derived from a region with increasing pressure on land. While many studies document positive average welfare effects of income diversification or off-farm income generation, the nuances of our findings for our research area may not hold in other regions. In order to better understand rural income portfolios, studies should distinguish better between income diversification and off- or non-

farm income generation, and move beyond the estimation of average welfare effects. Also combining static income and poverty measures with a dynamic vulnerability measure in an empirical welfare analysis, has proven to be a particularly interesting avenue to better understand income portfolios and their welfare effects.

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Tables

Table 1: Household characteristics across income diversification categories

	Pooled sample	Slightly diversified	Moderately diversified	Highly diversified
Number of observations	916	411	429	76
Female HH head (%)	9.0	11.2	7.9	7.0**
Education of HH head (years)	8.3	8.0	8.5*	8.5
	(0.15)	(0.23)	(0.23)	(0.53)
Age of HH head (years)	51.2	52.1	50.9	47.8**
	(0.48)	(0.72)	(0.70)	(1.47)
Number of adults	4.0	3.8	4.2**	4.3**
	(0.07)	(0.10)	(0.11)	(0.24)
Number of children	2.6	2.4	2.6	3.1***
	(0.06)	(0.09)	(0.09)	(0.21)
Land size (ha)	1.76	1.5	1.95***	2.33***
	(0.08)	(0.09)	(0.14)	(0.35)
Livestock units (TLU)	2.2	1.8	2.4***	2.9***
	(0.07)	(0.11)	(0.10)	(0.24)
Altitude (ft.)	983.1	1047.4	951.4***	813.7***
	(16.6)	(24.8)	(24.1)	(52.5)
Distance to forest (km)	4.3	3.6	4.2**	4.6***
	(0.08)	(0.22)	(0.11)	(0.13)
Distance to market (km)	4.4	4.5	4.4	3.7*
	(0.10)	(0.16)	(0.15)	(0.29)
Distance to main road (km)	2.5	2.6	2.5	2.3*
	(0.06)	(0.09)	(0.08)	(0.20)

We use t-tests to compare households with moderately or highly diversified income portfolios with households with slightly diversified income portfolios. Significant differences are indicated with *** p<0.01, ** p<0.05 or * p<0.1. Standard errors of the mean are reported between parentheses. Adults refer to household members above the age of 14; children refer to household members aged 14 or below. One tropical livestock unit (TLU) equals 1 cow/horse, 0.8 donkey, and 0.2 sheep/goat.

Table 2. Income, poverty and vulnerability over time (2014-2016) and across income diversification categories

	2014				2016			
	Total Sample	**Slightly diversified**	**Moderately diversified**	**Highly diversified**	**Total sample**	**Slightly diversified**	**Moderately diversified**	**Highly diversified**
Number of observations	458	182	233	43	458	229	196	33
Household income (1,000 UGX)	2,453 (2,198)	1,985 (2,186)	2,673*** (2,149)	3,240*** (2,145)	2,618 (2,683)	1,894 (2,049)	2,954** (2,657)	5,645*** (4,000)
Per capita income (1,000 UGX)	391 (375)	340 (388)	421** (377)	445* (275)	494*** (609)	367 (437)	566* (707)	941*** (732)
Poor households (%)	61.4	70.9	56.7***	46.5***	54.1***	66.4	46.4***	15.2***
Vulnerable households (%)	63.6	65.7	62.5**	61.1*	58.7***	63.0	54.9***	51.9***
Share of income from (%)								
Cropping	56.5 (30.0)	77.0 (32.7)	45.3** (18.7)	30.7*** (10.1)	47.4*** (35.3)	57.6 (42.5)	38.8*** (22.5)	27.1*** (13.4)
Livestock	20.1 (25.1)	8.8 (22.8)	27.7*** (25.1)	27.0*** (14.4)	26.3*** (28.7)	21.2 (33.3)	32.3* (23.3)	26.8*** (22.4)
Non-farm business	6.5 (14.3)	2.5 (7.1)	7.4*** (16.5)	18.2*** (15.6)	5.7 (16.4)	2.6 (14.4)	7.1** (17.2)	18.9** (17.5)
Wage employment	5.0 (18.0)	3.6 (22.2)	6.3 (14.6)	5.2*** (1.9)	4.8 (17.8)	3.5 (17.6)	6.3 (18.6)	5.3** (16.7)
Forest products	1.2 (6.8)	3.7 (0.8)	1.0*** (8.7)	2.8* (0.3)	1.1 (5.8)	5.9 (1.9)	1.3** (8.4)	1.6 (4.9)
Non labor transfers	10.8 (17.4)	4.4 (15.9)	12.3* (18.4)	16.1** (12.0)	14.7*** (26.8)	9.2 (31.1)	14.2 (22.5)	20.3*** (16.6)

We use t-tests to compare household in 2014 and 2016; and to compare households with moderately or highly diversified income portfolios with households with slightly diversified income portfolios. Significant differences are indicated with * p<0.1, ** p<0.05 or *** p<0.01. Standard deviations are reported between parentheses.

Table 3: Summary of fixed (FE) and random effects (RE) regression results estimating the average and quadratic effects of income diversification and off-farm income generation on per capita income, poverty and vulnerability

	Per capita income (log)		Poverty (binary)		Vulnerability	
	FE	**RE**	**FE**	**RE**	**FE**	**RE**
Simpson index	1.323***	1.364***	-0.507***	-0.496***	-0.073***	-0.099***
	(0.160)	(0.129)	(0.088)	(0.070)	(0.025)	(0.022)
Simpson index	0.996*	1.493***	-0.324	-0.351	-0.197**	-0.197**
	(0.551)	(0.432)	(0.302)	(0.235)	(0.088)	(0.076)
Simpson index^2	0.509	-0.201	-0.285	-0.227	-0.193**	-0.153**
	(0.820)	(0.645)	(0.449)	(0.351)	(0.131)	(0.113)
Share of off-farm income	1.576***	1.232***	-0.491***	-0.424***	-0.013	-0.001
	(0.123)	(0.091)	(0.072)	(0.050)	(0.022)	(0.017)
Share of off-farm income	1.885***	1.997***	-0.487**	-0.590***	-0.109*	-0.125**
	(0.350)	(0.289)	(0.206)	(0.163)	(0.061)	(0.053)
Share of off-farm income^2	-0.411	-0.974***	-0.005	0.210	0.127*	0.162**
	(0.436)	(0.349)	(0.257)	(0.196)	(0.077)	(0.065)

Full regression results are reported in appendix tables A2 to A5. Standard errors are reported in parentheses. Significant effects are indicated with * p<0.1, ** p<0.05 or *** p<0.01.

Table 4: Summary of random effects regression results estimating the heterogeneous welfare effects of income diversification and off-farm income generation

	Per capita income (log)		Poverty (binary)	
	I = Simpson index	**I = share of off-farm income**	**I = Simpson index**	**I = share of off-farm income**
Diversification (I)	1.199***	1.019***	-0.480***	-0.337***
	(0.248)	(0.181)	(0.135)	(0.100)
I * Education HH head	0.021	0.045***	0.002	-0.013*
	(0.027)	(0.017)	(0.014)	(0.007)
Education HH head	0.021*	0.019**	-0.015**	-0.012**
	(0.012)	(0.009)	(0.006)	(0.005)
Diversification (I)	1.605***	1.290***	-0.610***	-0.473***
	(0.161)	(0.108)	(0.087)	(0.060)
I * Land size	-0.148**	-0.038	0.070**	0.032
	(0.059)	(0.037)	(0.032)	(0.021)
Land size	0.084***	0.031**	-0.040**	-0.019**
	(0.030)	(0.015)	(0.016)	(0.008)
Diversification (I)	1.379***	1.235***	-0.496***	-0.427***
	(0.135)	(0.094)	(0.073)	(0.052)
I * Female HH head	-0.163	-0.037	0.0002	0.048
	(0.442)	(0.344)	(0.241)	(0.190)
Female HH head	-0.031	- 0.036	0.112	0.088
	(0.182)	(0.136)	(0.099)	(0.072)
Diversification (I)	2.438***	1.623***	-0.688***	-0.638***
	(0.457)	(0.324)	(0.249)	(0.080)
I * Age HH head	-0.021**	-0.008	0.004	0.004
	(0.009)	(0.006)	(0.005)	(0.003)
Age HH head	0.005	-0.001	0.001	0.001
	(0.004)	(0.003)	(0.002)	(0.002)
Diversification (I)	1.295***	1.489***	-0.495***	-0.545***
	(0.265)	(0.169)	(0.144)	(0.095)
I * Number of adults	0.017	0.065*	-0.0002	0.031
	(0.058)	(0.036)	(0.032)	(0.020)
Number of adults	-0.113***	- 0.081***	0.044***	0.032***
	(0.027)	(0.018)	(0.015)	(0.010))

Full regression results are reported in appendix tables A7 to A11. Standard errors are reported in parentheses. Significant effects are indicated with * p<0.1, ** p<0.05 or *** p<0.01.

Table 5: Summary of quantile fixed effects regression results estimating the effect of income diversification and off-farm income generation at different quantiles of per capita income and vulnerability

Per capita income (log)	**Q10**	**Q25**	**Q50**	**Q75**	**Q90**
Simpson index	2.081***	1.320***	1.307***	1.153***	0.961***
	(0.117)	(0.182)	(0.205)	(0.151)	(0.227)
Share of off-farm income	1.406***	1.394***	1. 371***	1.215***	1.174***
	(0.104)	(0.212)	(0.170)	(0.126)	(0.154)
Vulnerability	**Q10**	**Q25**	**Q50**	**Q75**	**Q90**
Simpson index	-0.104*	-0.096***	-0.085***	-0.071**	-0.050**
	(0.058)	(0.033)	(0.027)	(0.035)	(0.025)
Share of off-farm income	-0.064**	-0.058**	-0.055**	-0.028	-0.028
	(0.026)	(0.025)	(0.027)	(0.019)	(0.072)

Full regression results are reported in appendix tables A12 to A15. Standard errors are reported in parentheses. Significant effects are indicated with * p<0.1, ** p<0.05 or *** p<0.01.

Figures

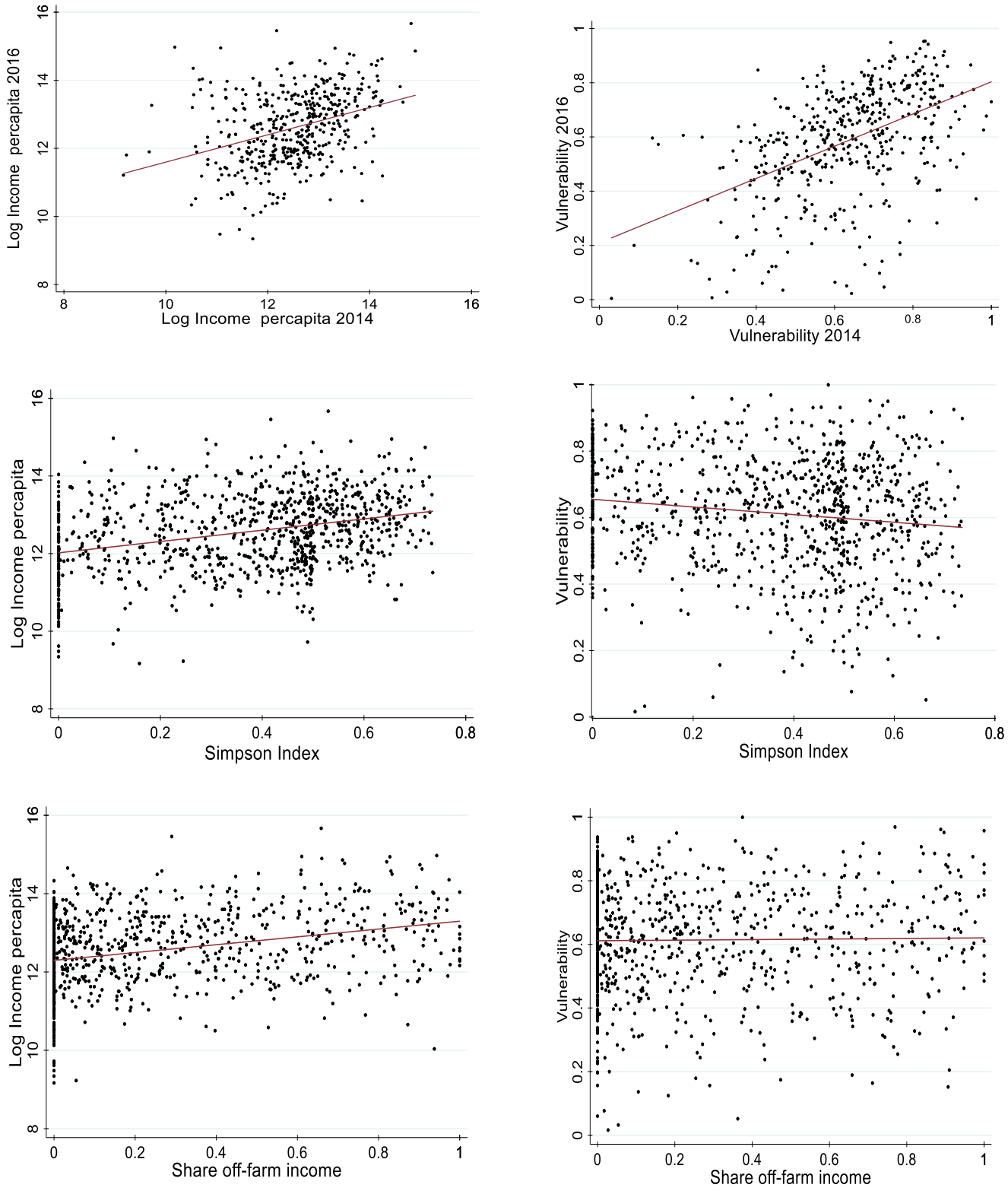

Figure 1: Correlation between income, vulnerability, Simpson index of diversification and share of off-farm income

Appendix

Table A1: Results of Feasible Generalized Least Squares regressions

	2014		2016	
	Income	**Variance**	**Income**	**Variance**
Female HH head	-0.087	-0.037	-0.092	-0.113
	(0.138)	(0.176)	(0.143)	(0.167)
Education of HH head	0.038***	0.009	0.026***	0.018*
	(0.009)	(0.012)	(0.009)	(0.011)
Age of HH head	-0.001	-0.004	-0.007**	-0.0003
	(0.003)	(0.004)	(0.003)	(0.004)
Number of adults	-0.080***	-0.010	-0.067***	0.002
	(0.017)	(0.021)	(0.026)	(0.030)
Number of children	-0.069***	-0.051*	-0.112***	-0.027
	(0.020)	(0.027)	(0.026)	(0.029)
Land size	-0.005	0.001	-0.066***	-0.023
	(0.015)	(0.018)	(0.016)	(0.016)
Livestock units	0.078***	0.017	0.161***	-0.021
	(0.018)	(0.026)	(0.021)	(0.023)
Altitude	-0.0003***	0.0002	-0.0001	0.0002*
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Distance to road	-0.034	-0.011	-0.039	-0.039
	(0.023)	(0.031)	(0.030)	(0.030)
Distance to market	-0.024*	-0.006	-0.035*	0.026
	(0.014)	(0.018)	(0.016)	(0.020)
Distance to forest	-0.044**	-0.017	-0.016	0.032
	(0.017)	(0.023)	(0.019)	(0.022)
Constant	13.805***	0.913***	13.432***	0.426
	(0.270)	(0.350)	(0.302)	(0.346)
N	458	458	458	458
R^2	0.178	0.021	0.257	0.048

Standard errors are reported in parentheses. Significant effects are indicated with * p<0.1, ** p<0.05 or *** p<0.01.

Table A2: Full fixed effects and random effects regression results of the average impact of diversification on income per capita, poverty and vulnerability

	Income per capita (log)		Poverty (binary)		Vulnerability	
	FE	**RE**	**FE**	**RE**	**FE**	**RE**
Simpson Index	1.323***	1.364***	-0.507***	-0.496***	-0.073***	-0.099***
	(0.160)	(0.129)	(0.088)	(0.070)	(0.025)	(0.022)
Female HH head	-0.072	-0.083	0.101**	0.112*		
	(0.097)	(0.115)	(0.051)	(0.061)		
Education HH head	0.019*	0.029***	-0.029***	-0.015***		
	(0.011)	(0.007)	(0.009)	(0.004)		
Age of HH head	-0.010*	-0.003	0.005*	0.002**		
	(0.005)	(0.002)	(0.003)	(0.001)		
Number of adults	-0.132***	-0.106***	0.053***	0.044***		
	(0.019)	(0.014)	(0.011)	(0.008)		
Number of children	-0.142***	-0.154***	0.036***	0.039***		
	(0.025)	(0.017)	(0.014)	(0.009)		
Land size	0.022*	0.016*	-0.013	-0.008		
	(0.012)	(0.009)	(0.015)	(0.006)		
Livestock units	0.069***	0.087***	-0.025**	-0.035***		
	(0.019)	(0.013)	(0.010)	(0.007)		
Altitude		-0.0002**		0.0001**		
		(0.0001)		(0.00004)		
Distance to road		-0.0001		0.002		
		(0.009)		(0.010)		
Distance to market		-0.038***		0.022***		
		(0.012)		(0.006)		
Distance to forest		0.012		0.002		
		(0.014)		(0.008)		
2016 dummy	0.005	0.004	-0.025	-0.035	-0.051***	-0.053***
	(0.051)	(0.047)	(0.028)	(0.026)	(0.007)	(0.007)
Constant	13.182***	12.614***	0.507***	0.614***	0.666***	0.676***
	(0.344)	(0.224)	(0.188)	(0.121)	(0.011)	(0.011)
N	916	916	916	916	916	916
R^2 - between	0.221	0.313	0.125	0.202	0.033	0.033
R^2 - within	0.283	0.273	0.181	0.169	0.105	0.103

Standard errors are reported in parentheses. Significant effects are indicated with * p<0.1, ** p<0.05 or *** p<0.01.

Table A3: Full fixed effects and random effects regression results of the quadratic impact of diversification on income per capita, poverty and vulnerability

	Income per capita (log)		Poverty (binary)		Vulnerability	
	FE	**RE**	**FE**	**RE**	**FE**	**RE**
Simpson Index	0.996*	1.493***	-0.324	-0.351	-0.197**	-0.197**
	(0.551)	(0.432)	(0.302)	(0.235)	(0.088)	(0.076)
Simpson Index^2	0.509	-0.201	-0.285	-0.227	-0.193**	-0.153**
	(0.820)	(0.645)	(0.449)	(0.351)	(0.131)	(0.113)
Female HH head	-0.074	-0.084	0.112**	0.111*		
	(0.097)	(0.115)	(0.051)	(0.062)		
Education HH head	0.019	0.029***	-0.029***	-0.015***		
	(0.017)	(0.007)	(0.009)	(0.004)		
Age of HH head	-0.010*	-0.003	0.005	0.002**		
	(0.005)	(0.002)	(0.003)	(0.001)		
Number of adults	-0.133***	-0.106***	0.053***	0.044***		
	(0.019)	(0.014)	(0.010)	(0.008)		
Number of children	-0.143***	-0.154***	0.040***	0.039***		
	(0.025)	(0.017)	(0.014)	(0.009)		
Land size	0.001	0.016	-0.001	-0.008		
	(0.014)	(0.011)	(0.008)	(0.006)		
Livestock units	0.070***	0.087***	-0.025**	-0.036***		
	(0.019)	(0.013)	(0.010)	(0.007)		
Altitude		-0.0002**		0.0001**		
		(0.0001)		(0.00004)		
Distance to road		-0.0001		0.002		
		(0.019)		(0.010)		
Distance to market		-0.038***		0.022***		
		(0.012)		(0.006)		
Distance to forest		0.012		0.002		
		(0.014)		(0.008)		
2016 dummy	0.007	0.003	-0.026	-0.035	-0.051***	-0.052***
	(0.051)	(0.047)	(0.028)	(0.026)	(0.007)	(0.007)
Constant	13.21***	12.60***	0.489**	0.60***	0.676***	0.684***
	(0.348)	(0.226)	(0.191)	(0.122)	(0.013)	(0.013)
N	916	916	916	916	916	916
R^2 - between	0.218	0.314	0.126	0.202	0.028	0.031
R^2 - within	0.284	0.272	0.181	0.170	0.109	0.107

Standard errors are reported in parentheses. Significant effects are indicated with * p<0.1, ** p<0.05 or *** p<0.01.

Table A4: Full fixed effects and random effects regression results of the average impact of the share of off-farm income on income per capita, poverty and vulnerability

	Income per capita (log)		Poverty (binary)		Vulnerability	
	FE	**RE**	**FE**	**RE**	**FE**	**RE**
Share of off-farm income	1.576***	1.232***	-0.491***	-0.424***	-0.013	-0.001
	(0.123)	(0.091)	(0.072)	(0.050)	(0.022)	(0.017)
Female HH head	-0.038	-0.043	0.087**	0.098*		
	(0.094)	(0.116)	(0.042)	(0.051)		
Education HH head	0.020*	0.026***	-0.028***	-0.014***		
	(0.011)	(0.007)	(0.009)	(0.004)		
Age of HH head	-0.011**	-0.003	0.005*	0.002**		
	(0.004)	(0.002)	(0.003)	(0.001)		
Number of adults	-0.114***	-0.102***	0.046***	0.042***		
	(0.017)	(0.013)	(0.010)	(0.008)		
Number of children	-0.139***	-0.142***	0.039***	0.034***		
	(0.022)	(0.016)	(0.013)	(0.009)		
Land size	0.002	0.020*	-0.007**	-0.010*		
	(0.012)	(0.011)	(0.003)	(0.006)		
Livestock units	0.098***	0.118***	-0.035**	-0.047***		
	(0.017)	(0.013)	(0.010)	(0.007)		
Altitude		-0.0002**		0.0001**		
		(0.0001)		(0.00004)		
Distance to road		-0.011		0.006		
		(0.019)		(0.010)		
Distance to market		-0.047***		0.025***		
		(0.012)		(0.006)		
Distance to forest		0.014		-0.003		
		(0.015)		(0.008)		
2016 dummy	-0.082*	-0.087**	-0.007	-0.002	-0.048***	-0.048***
	(0.046)	(0.044)	(0.027)	(0.025)	(0.007)	(0.007)
Constant	13.262***	12.726***	0.452***	0.575***	0.641***	0.638***
	(0.313)		(0.185)	(0.118)	(0.007)	(0.009)
		(0.218)				
N	916	916	916	916	916	916
R^2 - between	0.177	0.296	0.130	0.219	0.002	0.002
R^2 - within	0.396	0.378	0.201	0.187	0.089	0089

Standard errors are reported in parentheses. Significant effects are indicated with * p<0.1, ** p<0.05 or *** p<0.01.

Table A5: Full fixed effects and random effects regression results of the quadratic impact of the share of off-farm income on income per capita, poverty and vulnerability

	Income per capita (log)		Poverty (binary)		Vulnerability	
	FE	**RE**	**FE**	**RE**	**FE**	**RE**
Share of off-farm income	1.885***	1.997***	-0.487**	-0.590***	-0.109*	-0.125**
	(0.350)	(0.289)	(0.206)	(0.163)	(0.061)	(0.053)
Share of off-farm income^2	-0.411	-0.974***	-0.005	0.210	0.127*	0.162**
	(0.436)	(0.349)	(0.257)	(0.196)	(0.077)	(0.065)
Female HH head	-0.038	-0.045	0.100**	0.098		
	(0.094)	(0.115)	(0.049)	(0.061)		
Education HH head	0.013	0.025***	-0.028***	-0.014***		
	(0.015)	(0.007)	(0.009)	(0.004)		
Age of HH head	-0.011**	-0.002	0.005	0.002**		
	(0.005)	(0.002)	(0.003)	(0.001)		
Number of adults	-0.114***	-0.101***	0.046***	0.042***		
	(0.017)	(0.013)	(0.010)	(0.008)		
Number of children	-0.138***	-0.141***	0.039***	0.034***		
	(0.023)	(0.016)	(0.013)	(0.009)		
Land size	0.001	0.019*	-0.0003	-0.010*		
	(0.013)	(0.011)	(0.007)	(0.006)		
Livestock units	0.098***	0.116***	-0.035***	-0.047***		
	(0.017)	(0.013)	(0.010)	(0.007)		
Altitude		-0.0002**		0.0001**		
		(0.0001)		(0.00004)		
Distance to road		-0.013		0.007		
		(0.019)		(0.010)		
Distance to market		-0.048***		0.025***		
		(0.012)		(0.006)		
Distance to forest		0.012		0.003		
		(0.014)		(0.008)		
2016 dummy	-0.069	-0.056	0.007	-0.009	-0.052***	-0.053***
	(0.048)	(0.045)	(0.028)	(0.026)	(0.008)	(0.008)
Constant	13.23***	12.63***	0.452**	0.60***	0.647***	0.647***
	(0.315)	(0.219)	(0.186)	(0.119)	(0.008)	(0.010)
N	916	916	916	916	916	916
R^2 - between	0.181	0.306	0.130	0.222	0.006	0.009
R^2 - within	0.397	0.377	0.201	0.185	0.095	0.094

Standard errors are reported in parentheses. Significant effects are indicated with * p<0.1, ** p<0.05 or *** p<0.01.

Table A6: Full regression results of the difference-in-difference estimation of causality between income and income diversification.

	$Y_{i2016} - Y_{i2014}$	$I_{i2016} - I_{i2014}$
Simpson Index (2014)	1.465***	
	(0.242)	
Total income (2014)		0.028*
		(0.015)
Female HH head	0.211	-0.004
	(0.165)	(0.047)
Education HH head	0.002	-0.002
	(0.009)	(0.003)
Age of HH head	0.003	-0.002*
	(0.003)	(0.001)
Number of adults	0.008	0.008
	(0.020)	(0.006)
Number of children	0.002	-0.007
	(0.025)	(0.007)
Land size	-0.017	0.003
	(0.015)	(0.005)
Livestock units	0.012	0.004
	(0.020)	(0.006)
Altitude	-0.00003	0.00004
	(0.0001)	(0.00003)
Distance to road	-0.025	-0.016
	(0.030)	(0.008)
Distance to market	-0.013	-0.011**
	(0.017)	(0.004)
Distance to forest	-0.007	-0.013**
	(0.022)	(0.006)
Constant	-0.585*	12.726***
	(0.352)	(0.218)
N	458	458
R^2	0.108	0.050

Total income is specified in log terms. Standard errors are reported in parentheses. Significant effects are indicated with * p<0.1, ** p<0.05 or *** p<0.01.

Table A7: Full random effects regression results of the heterogeneous effects of income diversification and the share of off-farm income based on the interaction with education of the household head

	Income per capita (log)		Poverty (binary)	
	I = Simpson index	**I = share of off-farm income**	**I = Simpson index**	**I = share of off-farm income**
Diversification (I)	1.199***	1.019***	-0.480***	-0.337***
	(0.248)	(0.181)	(0.135)	(0.100)
I * Education of HH head	0.021	0.045***	0.002	-0.013*
	(0.027)	(0.017)	(0.014)	(0.007)
Education of HH head	0.021*	0.019**	-0.015**	-0.012**
	(0.012)	(0.009)	(0.006)	(0.005)
Female HH head	-0.084	-0.043	0.112*	0.098**
	(0.114)	(0.116)	(0.062)	(0.061)
Age of HH head	-0.003	-0.003**	0.002*	0.002
	(0.002)	(0.002)	(0.001)	(0.001)
Number of adults	-0.106***	-0.102***	0.044***	0.043***
	(0.014)	(0.013)	(0.008)	(0.008)
Number of children	-0.154***	-0.141***	0.039***	0.034***
	(0.017)	(0.013)	(0.009)	(0.009)
Land size	0.016	0.021***	-0.008	-0.011*
	(0.011)	(0.011)	(0.006)	(0.006)
Livestock units	0.087***	0.119***	-0.035***	-0.048***
	(0.013)	(0.013)	(0.007)	(0.007)
2016 dummy	0.003	-0.086*	-0.035	-0.003
	(0.047)	(0.044)	(0.026)	(0.026)
Altitude	-0.0002**	-0.0002**	0.0001**	0.0001**
	(0.0001)	(0.0001)	(0.00004)	(0.00004)
Distance to road	-0.0004	-0.012	0.003	0.007
	(0.019)	(0.019)	(0.010)	(0.010)
Distance to market	-0.038***	-0.047***	0.022***	0.025***
	(0.012)	(0.012)	(0.006)	(0.006)
Distance to forest	-0.012	0.013	0.002	-0.003
	(0.014)	(0.014)	(0.008)	(0.008)
Constant	12.671***	12.779***	0.608***	0.553***
	(0.236)	(0.221)	(0.128)	(0.119)
N	916	916	916	916
R^2 - between	0.316	0.303	0.202	0.223
R^2 -within	0.271	0.373	0.168	0.184

Standard errors are reported in parentheses. Significant effects are indicated with * p<0.1, ** p<0.05 or *** p<0.01.

Table A8: Full random effects regression results of the heterogeneous effects of income diversification and the share of off-farm income based on the interaction with landholdings

	Income per capita (log)		Poverty (binary)	
	I = Simpson index	**I = share of off-farm income**	**I = Simpson index**	**I = share of off-farm income**
Diversification (I)	1.605***	1.290***	-0.610***	-0.473***
	(0.161)	(0.108)	(0.087)	(0.060)
I * Land size	-0.148**	-0.038	0.070**	-0.032
	(0.059)	(0.037)	(0.032)	(0.021)
Land size	0.084***	0.031**	-0.040**	-0.019**
	(0.030)	(0.015)	(0.016)	(0.008)
Female HH head	-0.076	-0.046	0.109*	0.100**
	(0.114)	(0.116)	(0.062)	(0.061)
Education of HH head	0.028***	0.025***	-0.015***	-0.014***
	(0.007)	(0.007)	(0.004)	(0.004)
Age of HH head	-0.003	-0.003	0.002*	0.002
	(0.002)	(0.002)	(0.001)	(0.001)
Number of adults	-0.107***	-0.102***	0.045***	0.042***
	(0.014)	(0.013)	(0.008)	(0.008)
Number of children	-0.151***	-0.141***	0.037***	0.034***
	(0.017)	(0.016)	(0.009)	(0.009)
Livestock units	0.087***	0.119***	-0.036***	-0.048**
	(0.013)	(0.013)	(0.007)	(0.007)
2016 dummy	0.004	-0.087**	-0.035	-0.003
	(0.047)	(0.044)	(0.026)	(0.025)
Altitude	-0.0002**	-0.0002***	0.0001**	0.0001**
	(0.0001)	(0.0001)	(0.00004)	(0.00004)
Distance to road	-0.004	-0.011	0.001	0.006
	(0.019)	(0.019)	(0.010)	(0.010)
Distance to market	-0.038***	-0.047***	0.022***	0.025***
	(0.012)	(0.012)	(0.006)	(0.006)
Distance to forest	-0.011	0.014	0.002	-0.003
	(0.014)	(0.015)	(0.008)	(0.008)
Constant		12.710***	0.663***	0.587***
	12.507***	(0.218)	(0.123)	(0.118)
	(0.226)			
N	916	916	916	916
R^2 - between	0.323	0.298	0.207	0.224
R^2 -within	0.273	0.377	0.172	0.186

Standard errors are reported in parentheses. Significant effects are indicated with * p<0.1, ** p<0.05 or *** p<0.01.

Table A9: Full random effects regression results of the heterogeneous effects of income diversification and the share of off-farm income based on the interaction with female-headed household

	Income per capita (log)		Poverty (binary)	
	I = Simpson index	**I = share of off-farm income**	**I = Simpson index**	**I = share of off-farm income**
Diversification (I)	1.379***	1.235***	-0.496***	-0.427***
	(0.135)	(0.094)	(0.073)	(0.052)
I * Female head	-0.163	-0.037	0.0002	0.048
	(0.442)	(0.344)	(0.241)	(0.190)
Female head	-0.031	- 0.036	0.112	0.088
	(0.182)	(0.136)	(0.099)	(0.072)
Education of HH head	0.029***	0.026***	-0.015***	-0.014***
	(0.007)	(0.007)	(0.004)	(0.004)
Age of HH head	-0.003	- 0.003	0.002*	0.002
	(0.002)	(0.002)	(0.001)	(0.001)
Number of adults	-0.106***	-0.102***	0.044***	0.042***
	(0.014)	(0.013)	(0.008)	(0.008)
Number of children	-0.154***	-0.142***	0.039***	0.035***
	(0.017)	(0.016)	(0.009)	(0.009)
Land size	0.016	0.020*	-0.008	-0.010*
	(0.011)	(0.011)	(0.006)	(0.006)
Livestock units	0.087***	0.118***	-0.035***	-0.047**
	(0.013)	(0.013)	(0.007)	(0.007)
2016 dummy	0.004	-0.087**	-0.035	-0.003
	(0.047)	(0.044)	(0.026)	(0.026)
Altitude	-0.0002**	-0.0002***	0.0001*	0.0001**
	(0.0001)	(0.0001)	(0.00004)	(0.00004)
Distance to road	-0.0003	-0.011	0.002	0.006
	(0.019)	(0.019)	(0.010)	(0.010)
Distance to market	-0.038***	-0.047***	0.022***	0.025***
	(0.012)	(0.012)	(0.006)	(0.006)
Distance to forest	-0.012	0.014	0.002	-0.003
	(0.014)	(0.015)	(0.008)	(0.008)
Constant	12.607***	12.726***	0.614***	0.574***
	(0.224)	(0.218)	(0.121)	(0.118)
N	916	916	916	916
R^2 - between	0.314	0.296	0.202	0.219
R^2 -within	0.272	0.378	0.169	0.187

Standard errors are reported in parentheses. Significant effects are indicated with * p<0.1, ** p<0.05 or *** p<0.01.

Table A10: Full random effects regression results of the heterogeneous welfare effects of income diversification and the share of off-farm income based on the interaction with age of the household head

	Income per capita (log)		Poverty (binary)	
	I = Simpson index	**I = share of off-farm income**	**I = Simpson index**	**I = share of off-farm income**
Diversification (I)	2.438***	1.623***	-0.688***	-0.638***
	(0.457)	(0.324)	(0.249)	(0.080)
I * Age of HH head	-0.021**	-0.008	0.004	0.004
	(0.009)	(0.006)	(0.005)	(0.003)
Age of HH head	0.005	-0.001	0.001	0.001
	(0.004)	(0.003)	(0.002)	(0.002)
Female HH head	-0.069	-0.041	0.110*	0.096
	(0.114)	(0.116)	(0.062)	(0.061)
Education of HH head	0.029***	0.026***	-0.015***	-0.015***
	(0.007)	(0.007)	(0.004)	(0.004)
Number of adults	-0.103***	-0.102***	0.044***	0.042***
	(0.014)	(0.013)	(0.008)	(0.008)
Number of children	-0.153***	-0.141***	0.039***	0.034***
	(0.017)	(0.016)	(0.009)	(0.009)
Land size	0.016	0.020*	-0.008	-0.010*
	(0.011)	(0.011)	(0.006)	(0.006)
Livestock units	0.087***	0.118***	-0.035***	-0.047***
	(0.013)	(0.013)	(0.007)	(0.007)
2016 dummy	0.012	-0.088**	-0.036	-0.002
	(0.048)	(0.044)	(0.026)	(0.025)
Altitude	-0.0002**	-0.0002***	0.0001**	0.0001**
	(0.0001)	(0.0001)	(0.00004)	(0.00004)
Distance to road	-0.001	-0.012	0.003	0.006
	(0.019)	(0.019)	(0.010)	(0.010)
Distance to market	-0.038***	-0.048***	0.022***	0.025***
	(0.011)	(0.012)	(0.006)	(0.006)
Distance to forest	-0.013	0.015	0.003	-0.004
	(0.014)	(0.015)	(0.008)	(0.008)
Constant	12.206***	12.624***	0.614***	0.631***
	(0.277)	(0.232)	(0.121)	(0.126)
N	916	916	916	916
R^2 - between	0.325	0.295	0.206	0.220
R^2 -within	0.270	0.381	0.166	0.189

Standard errors are reported in parentheses. Significant effects are indicated with * p<0.1, ** p<0.05 or *** p<0.01.

Table A11: Full random effects regression results of the heterogeneous effects of income diversification and the share of off-farm income based on the interaction with number of adults in the household

	Income per capita (log)		Poverty (binary)	
	I = Simpson index	**I = share of off-farm income**	**I = Simpson index**	**I = share of off-farm income**
Diversification (I)	1.295***	1.489***	-0.495***	-0.545***
	(0.265)	(0.169)	(0.144)	(0.095)
I * Number of adults	0.017	0.065*	-0.0002	0.031
	(0.058)	(0.036)	(0.032)	(0.020)
Number of adults	-0.113***	- 0.081***	0.044***	0.032***
	(0.027)	(0.018)	(0.015)	(0.010)
Female HH head	-0.084	-0.034	0.112*	0.093
	(0.115)	(0.116)	(0.062)	(0.061)
Education of HH head	0.029***	0.026***	-0.015***	-0.015***
	(0.007)	(0.007)	(0.004)	(0.004)
Age of HH head	-0.003	-0.003	0.002*	0.002
	(0.002)	(0.002)	(0.001)	(0.001)
Number of children	-0.154***	-0.141***	0.039***	0.034***
	(0.017)	(0.016)	(0.009)	(0.009)
Land size	0.016	0.020*	-0.008	-0.010*
	(0.011)	(0.011)	(0.006)	(0.006)
Livestock units	0.087***	0.118***	-0.035***	-0.047***
	(0.013)	(0.013)	(0.007)	(0.007)
2016 dummy	0.004	-0.089**	-0.035	-0.001
	(0.047)	(0.044)	(0.026)	(0.025)
Altitude	-0.0002**	-0.0002***	0.0001**	0.0001**
	(0.0001)	(0.0001)	(0.00004)	(0.00004)
Distance to road	-0.0003	-0.011	0.002	0.006
	(0.019)	(0.019)	(0.010)	(0.010)
Distance to market	-0.038***	-0.047***	0.022***	0.024***
	(0.012)	(0.012)	(0.006)	(0.006)
Distance to forest	0.012	0.015	-0.002	-0.004
	(0.014)	(0.015)	(0.008)	(0.008)
Constant	12.642***	12.643***	0.614***	0.613***
	(0.243)	(0.222)	(0.131)	(0.120)
N	916	916	916	916
R^2 - between	0.312	0.296	0.202	0.217
R^2 -within	0.273	0.381	0.169	0.192

Standard errors are reported in parentheses. Significant effects are indicated with * p<0.1, ** p<0.05 or *** p<0.01.

Table A12: Full quantile fixed effects regression results for the heterogeneous effect of income diversification on income per capita (log)

	Q10	**Q25**	**Q50**	**Q75**	**Q90**
Simpson Index	2.081***	1.320***	1.307***	1.153***	0.961***
	(0.117)	(0.182)	(0.205)	(0.151)	(0.227)
Female HH head	-0.163**	-0.097**	-0.069**	-0.154**	-0.204***
	(0.072)	(0.045)	(0.031)	(0.066)	(0.064)
Education of HH head	0.021*	0.018**	0.049***	0.029**	0.031*
	(0.012)	(0.008)	(0.011)	(0.012)	(0.017)
Age of HH head	-0.005***	-0.014**	-0.006**	0.003	-0.0002
	(0.001)	(0.006)	(0.003)	(0.002)	(0.0008)
Number of adults	-0.149***	-0.098***	-0.127***	-0.146***	-0.133***
	(0.054)	(0.023)	(0.021)	(0.018)	(0.019)
Number of children	-0.185***	-0.175***	-0.150***	-0.167***	-0.156***
	(0.066)	(0.029)	(0.013)	(0.017)	(0.027)
Land size	0.008**	0.024***	0.033***	0.034***	0.028***
	(0.004)	(0.001)	(0.002)	(0.013)	(0.008)
Livestock units	0.097***	0.080***	0.072***	0.069***	0.086***
	(0.020)	(0.015)	(0.012)	(0.016)	(0.017)
2016 dummy	-0.403	-0.110	-0.017	0.202*	-0.389
	(0.322)	(0.048)	(0.118)	(0.119)	(0.321)
Altitude	-0.0005*	-0.0001	-0.0004***	-0.0004**	-0.0001
	(0.0003)	(0.0001)	(0.0001)	(0.0002)	(0.0002)
Distance to road	-0.013**	-0.033*	-0.014**	-0.045***	-0.081***
	(0.005)	(0.017)	(0.007)	(0.014)	(0.015)
Distance to market	-0.049*	-0.029**	-0.034**	-0.038*	-0.032*
	(0.022)	(0.012)	(0.015)	(0.022)	(0.019)
Distance to forest	0.023	0.016	0.024	0.013	0.022
	(0.045)	(0.054)	(0.018)	(0.013)	(0.051)
N	916	916	916	916	916

Standard errors are reported in parentheses. Significant effects are indicated with * p<0.1, ** p<0.05 or *** p<0.01.

Table A13: Full quantile fixed effects regression results for the heterogeneous effect of the share of off-farm income on income per capita (log)

	Q10	**Q25**	**Q50**	**Q75**	**Q90**
Share of off-farm income	1.406***	1.394***	1. 371***	1.215***	1.174***
	(0.104)	(0.212)	(0.170)	(0.126)	(0.154)
Female HH head	-0.464	-0.235*	-0.106	-0.156	-0.492
	(0.348)	(0.130)	(0.075)	(0.102)	(0.393)
Education of HH head	0.029***	0.016***	0.039***	0.029***	0.018*
	(0.003)	(0.005)	(0.011)	(0.004)	(0.010)
Age of HH head	0.005**	-0.004***	-0.006***	-0.001	-0.005
	(0.002)	(0.001)	(0.002)	(0.002)	(0.008)
Number of adults	-0.067***	-0.097***	-0.075***	-0.094***	-0.129***
	(0.014)	(0.019)	(0.021)	(0.010)	(0.022)
Number of children	-0.135***	-0.131***	-0.164***	-0.170***	-0.182***
	(0.028)	(0.010)	(0.017)	(0.013)	(0.024)
Land size	0.033*	0.019***	0.011*	0.013**	0.012**
	(0.018)	(0.002)	(0.006)	(0.006)	(0.006)
Livestock units	0.048***	0.152***	0.137***	0.129***	0.081***
	(0.018)	(0.023)	(0.017)	(0.016)	(0.027)
2016 dummy	-0.058	0.060	-0.149***	-0.095**	-0.134
	(0.055)	(0.049)	(0.024)	(0.048)	(0.087)
Altitude	-0.0002***	-0.0004***	-0.0004***	-0.00005	-0.0001
	(0.00004)	(0.0001)	(0.0001)	(0.00007)	(0.0001)
Distance to road	-0.098	-0.055**	-0.029	-0.002	-0.035
	(0.065)	(0.028)	(0.027)	(0.009)	(0.073)
Distance to market	-0.028	-0.077***	-0.080***	-0.043***	-0.045*
	(0.024)	(0.021)	(0.016)	(0.005)	(0.023)
Distance to forest	0.015**	0.025	0.005	0.011	0.052
	(0.006)	(0.021)	(0.020)	(0.015)	(0.063)
N	916	916	916	916	916

Standard errors are reported in parentheses. Significant effects are indicated with * p<0.1, ** p<0.05 or *** p<0.01.

Table A12: Full quantile fixed effects regression results for the heterogeneous effect of income diversification on vulnerability

	Q10	Q25	Q50	Q75	Q90
Simpson Index	-0.104*	-0.096***	-0.085***	-0.071**	-0.050**
	(0.058)	(0.033)	(0.027)	(0.035)	(0.025)
2016 dummy	-2.17e+10	-5.07e+09	1.77e+11	248859.6	-6.48e+12
	(8.21e+10)	(1.57e+11)	(8.05e+11)	(674580.5)	(2.35e+13)
N	916	916	916	916	916

Standard errors are reported in parentheses. Significant effects are indicated with * p<0.1, ** p<0.05 or *** p<0.01.

Table A13: Full quantile fixed effects regression results for the heterogeneous effect of the share of off-farm income on vulnerability

	Q10	Q25	Q50	Q75	Q90
Share of off-farm income	-0.064**	-0.058**	-0.055**	-0.028	-0.028
	(0.026)	(0.025)	(0.027)	(0.019)	(0.072)
2016 dummy	1.13e+10	1.72e+08	2.09e+08	-2634112	-6511377
	(9.00e+10)	(4.82e+08)	(2.97e+09)	(1.79e+07)	(3.75e+07)
N	916	916	916	916	916

Standard errors are reported in parentheses. Significant effects are indicated with * p<0.1, ** p<0.05 or *** p<0.01.